Chapter 2
THE WATER SUPPLY PLANNING PROCESS

PROCESS OVERVIEW

This section describes the planning process that was undertaken to develop the *Lower East Coast Regional Water Supply Plan* (LEC Plan). The structure of the iterative process used is summarized in the following steps that are described in this plan:

1. Define goals and objectives (**Chapter 1**, **Chapter 2**, and **Appendix A**)
2. Develop evaluation tools (**Chapter 2**, **Appendix E**, and **Appendix F**)
3. Develop performance measures (**Chapter 2**, **Chapter 4**, and **Appendix D**)
4. Estimate current and future base case (without action) conditions (**Chapter 4** and **Appendix B**)
5. Identify problems and issues, including quantification of supplies, demands, and projected shortfalls (**Chapter 4**)
6. Identify options for inclusion in an alternative (**Chapter 4**)
7. Evaluate water management systemwide performance of the alternative(s); identify demands met and not met (**Chapter 4** and **Appendix H**)
8. Develop and analyze solutions and water supply options (**Chapter 5** and **Appendix H**)
9. Develop recommendations based on the results of evaluations (**Chapter 6**)
10. Develop action plans and funding plans to implement the recommendations (**Chapter 6**)

To implement this process for the LEC Plan, staff first worked with the LEC Regional Water Supply Advisory Committee to develop an overall goal and objectives for the plan. These were presented and discussed in **Chapter 1**. Particular attention was paid to ensure that the water supply goal and objectives gave balanced consideration to meeting urban, agricultural, and natural system needs.

At the same time, steps were taken to develop or improve the hydrologic modeling tools that would be used to test and evaluate systemwide performance under various alternatives. Key hydrologic modeling tools include the South Florida Water Management Model (SFWMM) and a series of subregional ground water models that were developed to address localized geographic areas.

Performance measures were developed based on outputs from the hydrologic modeling tools and results of related investigations. The performance measures are used as indicators of the degree to which the water supply objectives are being met. The performance measures identify whether the proposed alternative system is providing water with appropriate timing, frequency, and duration; in sufficient quantities; and at the proper locations to meet the objectives of the plan.

Next, the systemwide performance of the water management system was assessed under conditions that presently occur, or that will occur in the future, without any actions being taken based on the LEC Plan. These two without-action conditions are called the 1995 (current) base case and the 2020 (future) base case. The year 1995 was selected as one anchor year because it represented the latest year for which complete historical dates could be incorporated into the plan. The year 2020 was selected as the other anchor because it represented the end point of a 20-year planning horizon (as stipulated in Chapter 373, F.S.), based on the completion date of this plan (May 2000). The 1995 and 2020 dates are also consistent with the time frames of the *Districtwide Water Supply Assessment* (SFWMD, 1998c) and other regional water supply plans.

The 1995 base case includes land use, population, and water demands, as well as the water management system and operating rules that applied at the time of the analysis (1999). The 2020 base case includes projections of 2020 land use, population, and water demands. It also includes modifications to the water management system, such as the Everglades Construction Project and the Kissimmee River Restoration, that are scheduled to be implemented by 2020.

Analyses of these baseline conditions, which are described in subsequent chapters, show that significant water resource problems can be expected to occur throughout the region unless actions are taken to improve water supplies, redistribute flows, or reduce expected demands. Results of the model simulations indicate that frequent water restrictions may occur within the coastal urbanized and interior farming areas. Serious environmental concerns were also identified as likely to occur in Lake Okeechobee, the Everglades Protection Area, and the St. Lucie and Caloosahatchee estuaries.

Having defined the type and severity of potential future problems the planning process then began to develop and analyze alternative solutions. The first solution was to incorporate features of the *Interim Plan for Lower East Coast Regional Water Supply* (SFWMD, 1998b) and implement the various projects and activities recommended by the *Central and Southern Florida Project Comprehensive Review Study Final Feasibility Report and Programmatic Environmental Impact Statement* (Restudy) (USACE and SFWMD, 1999) that would be in place by 2020. Results of this analysis indicated that many of the problems identified to occur in the future were resolved. The most promising methods available to enhance water supply was to implement options that have been identified in previous LEC planning documents and additional new options.

The recommendations of this plan are based on the results of the alternatives analyzed and provide a blueprint to address the future water needs of the region. Recommendations of the *Caloosahatchee Water Management Plan* (CWMP) (SFWMD,

2000d) also have been included. The analysis of the Restudy components and the water supply planning alternative provided insight into how the options functioned together and how an integrated system could be designed. Some of the proposed recommendations will be implemented as part of the Comprehensive Everglades Restoration Plan (CERP), its associated critical projects, feasibility studies, and project implementation reports. Other recommendations suggest actions to address regional and local water supply needs that should be implemented via the LEC Plan and the MFL recovery and prevention plans. More detailed implementation strategies, funding, and five-year water resource development work plans will be prepared based on recommendations contained herein.

IMPLEMENTING THE PROCESS

Goal Clarification (Step 1)

The overall goal of Chapter 373, F.S., is to ensure the sustainability of water resources of the state (Section 373.016, F.S.). Chapter 373, F.S., provides the District with several tools to carry out this responsibility. These tools have various levels of resource protection standards. Water resource protection standards in Chapter 373, F.S., must be applied together as a whole to meet this goal. Pursuant to Parts II and IV of Chapter 373, F.S., surface water management and Consumptive Use Permitting (CUP) regulatory programs must prevent **harm** to the water resource. MFLs must be set at the point at which further withdrawals could cause **significant harm** to the water resources or ecology of the area. Water shortage statutes, on the other hand, dictate that permitted water supplies must be restricted in a manner that prevents **serious harm** from occurring to the water resources. Other protection tools include reservation of water for fish and wildlife, or health and safety (Section 373.223[3], F.S.), and aquifer zoning to prevent undesirable uses of the ground water (Section 373.036, F.S.).

The levels of impacts cited above, harm, significant harm, and serious harm, are relative resource protection terms. Each plays a role to help achieve the ultimate goal, which is a sustainable water resource. The role of MFLs is shown conceptually in **Figure 7**.

Consumptive Use Permitting Role - Harm Standard and Level of Certainty

Harm Standard

The resource protection criteria used for CUP are based on the level of impact that is considered harmful to the water resource. These criteria are applied to various resource functions to establish the range of hydrologic change that can occur without incurring harm. The hydrological criteria include water level, duration, and frequency components and are used to define the amount of water that can be allocated from the resource. Saltwater intrusion, wetland drawdown, aquifer mining, and pollution prevention criteria in Chapter 40E-2, F.A.C., together define the harm standard for purposes of consumptive

use allocation. These harm criteria are currently applied using climate conditions that represent an assumed 1-in-10 year level of certainty.

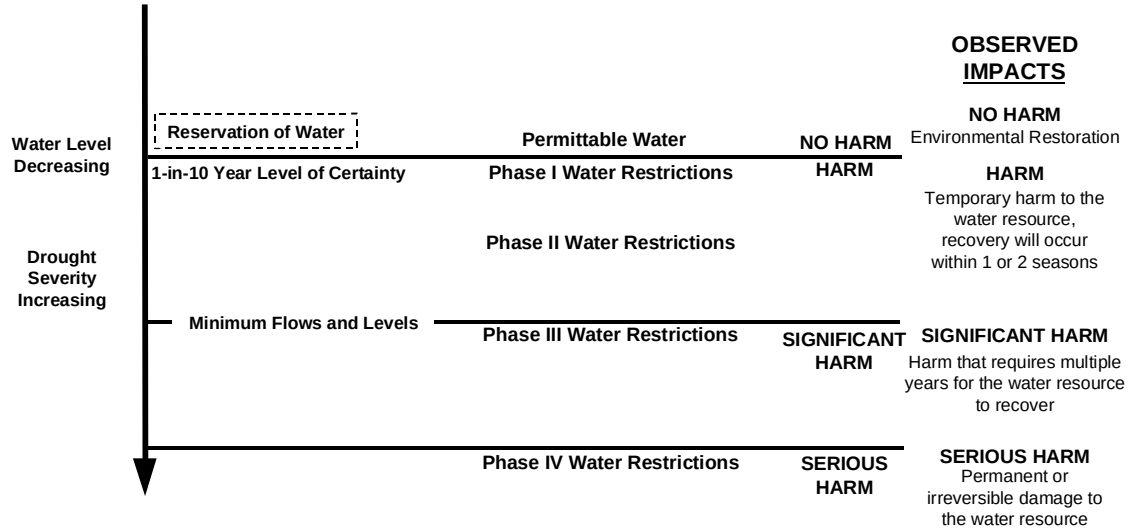

Figure 7. Conceptual Relationship Among the Harm, Serious Harm, and Significant Harm Standards

Level of Certainty

The level of certainty may be characterized as the point to which ground water or surface water can be drawn down on a reoccurring basis, based on the severity of a drought event, without harming the water resources. The regulatory level represents the point of maximum resource development that protects the water resources from harm and provides some degree of certainty to water use permittees. Another implication of the level of certainty in the planning process is that it defines where water resource development projects need to be implemented to meet projected reasonable demands (Section 373.0361, F.S.).

Wetlands Protection

Section 3.3, Environmental Impacts, of the District's Basis of Review for Water Use Permit Applications (SFWMD, 1997d) requires that withdrawals of water must not cause adverse impacts to environmental features that are sensitive to magnitude, seasonal timing, and duration of inundation. Maintaining appropriate wetland hydrology (water levels and hydroperiod) is scientifically accepted as the single most critical factor in maintaining a viable wetland ecosystem (Duever, 1988; Mitch and Gosselink, 1986; Erwin, 1991). Water use induced drawdowns under wetlands potentially affect water levels, hydroperiod, and the areal extent of the wetland. A guideline of no greater than one foot of drawdown at the edge of a wetland after 90 days of no recharge and maximum day withdrawals is used currently for CUP purposes to indicate no adverse impacts. For CUP purposes, wetlands are delineated using the statewide methodology as described in Chapter 62-340, F.A.C.

The wetland protection criterion used in the modelling performance measures is defined as follows: ground water level drawdowns induced by cumulative pumping withdrawals in areas that are classified as wetlands should not exceed one foot at the edge of the wetland for more than one month during a 12-month drought condition that occurs as frequently as once every 10 years.

The District began a research project in 1995 to support development of wetland drawdown criteria. This project involves long-term monitoring of wellfields and wetland systems. The wetland protection criterion regarding the relationship between water use drawdowns and impacts to specific wetland types will be reviewed in the future as these field data become available.

Projects Needed to Meet Demands

This plan defines the water resource and water supply development projects that are needed to assure reasonable-beneficial demands will be met. The regulatory process is one of several plan implementation tools. In order to be consistent with the plan, CUP applications are reviewed by using the same level of certainty that was used for the planning analysis, and similar resource protection constraints, on a smaller scale.

1-in-10 Year Level of Certainty

This plan must also meet the water demands for a 1-in-10 year drought event (Section 373.036, F.S.). This level of certainty planning criterion is incorporated into the modeling targets for the LEC Plan. The level-of-certainty planning criteria are designed to prevent harm to the resources up to a 1-in-10 year drought event. These criteria are not intended to be a minimum flow and level. For drought conditions greater than a 1-in-10 year event, it may be necessary to decrease water withdrawals to avoid causing significant harm to the resource. Water shortage triggers are water levels at which phased restrictions will be declared under the District's water shortage program. The District can use these triggers to curtail withdrawals and help prevent water levels from declining to and below a level where significant harm may occur to the resource could potentially occur.

Water Shortage Role - Serious Harm Standard

Pursuant to Section 373.246, F.S., water shortage declarations are designed to prevent serious harm from occurring to water resources. Serious harm, the ultimate harm to the water resources that was contemplated under Chapter 373, F.S., can be interpreted as long-term, irreversible, or permanent impacts to the water resource. Declaration of water shortages by the Governing Board can thus be used as a tool to prevent serious harm.

When droughts occur, water users increase the amount of withdrawals, typically for irrigation or outside use, to supplement water not provided by rainfall. In general, the more severe the drought, the more supplemental water is needed, and the more likely it becomes that water shortage restrictions will be imposed. These increased withdrawals also increase the potential for serious harm to the water resource.

By basing the CUP criteria on a specific and uniform level of certainty, it is possible to estimate how often water may be restricted by water shortage declaration. Water shortage restrictions may be imposed due to climactic events, continued decline in water levels, and/or saltwater intrusion and provide a means to curtail human use in the face of decreasing supplies. Each water level trigger corresponds to a particular level of water shortage restriction. These restrictions act to apportion the available resource among uses, including the environment, in a manner that shares the adversity resulting from a drought event. Adoption of resource protection criteria as water shortage trigger indicators also reminds users of the risks of damage and potential for loss due to water shortages.

The District has implemented its water shortage authority by restricting consumptive uses based on the concept of shared adversity between users and the water resources (Chapter 40E-21, F.A.C.). Under this program, different levels or phases of water shortage restrictions with varying levels of severity are imposed relative to the severity of drought conditions. The four phases of current water shortage restrictions are based on progressively increasing resource impacts, leading up to serious harm. Under the District program, Phase I and II water shortages primarily reduce water use through conservation techniques and minor use restrictions, such as restrictions on car washing and lawn watering. Phases III and IV, however, require use cutbacks that are associated with some level of economic impact to the users, such as the potential for crop damage due to agricultural irrigation restrictions.

Determining Environmental Water Needs

Water demands for urban and agricultural users are better established and known than environmental water demands. Urban and agricultural water uses are considered in the plan based on historical data and irrigation practices. These are projected into the future considering changes in conservation practices, population, land use, and irrigation systems. Urban, agricultural, and industrial uses of water are protected through the CUP process.

On the other hand, environmental demands have not historically been explicitly defined as a component in the management of the regional water system, with the possible exception of the rainfall-based operational plans being developed for Modified Water Delivery Project for Everglades National Park. To clarify the LEC Plan’s objective of protecting and enhancing the environment and translate it into operational terms, two processes were implemented during plan development. The first was a process to determine appropriate MFLs for Lake Okeechobee, the Everglades Protection Area, and the Biscayne aquifer. The second was the effort undertaken during development of the Restudy to define restoration. Results of these efforts are briefly discussed below. The state provides an explicit tool to ensure availability of water for natural systems.

Reservations of Water

Chapter 373, F.S., gives the District authority to reserve water for environmental purposes:

> The governing board or the department, by regulation, may reserve from use by permit applicants, water in such locations and quantities, and for such seasons of the year, as in its judgment may be required for the protection of fish and wildlife or the public health and safety (Section 373.223(3), F.S.).

Water reserved under this statute cannot be allocated for use under the CUP program. The reservation statute may be used effectively as the standard for the restoration of water resources. It is construed to offer a higher level of protection for fish and wildlife than the significant harm standard that applies to MFLs.

One of the most explicit protections of water supplies for natural systems in the LEC Planning Area is set forth in the Everglades Forever Act. In addition to its water quality components, the Everglades Forever Act requires establishment of “programs and projects to improve the water quantity reaching the Everglades Protection Area at optimum times and improve hydroperiod deficiencies in the Everglades ecosystem” (Section 373. 4592(4)(b), F.S.). Although the Everglades Forever Act mandates this broad reaching goal, it explicitly directs the District to utilize existing legal mechanisms in Chapter 373, F.S., to implement the hydroperiod enhancement program. The Everglades Forever Act generally refers to the District's other authority to reserve water for environmental purposes. The use of reservations may also be appropriate for setting aside water from allocation necessary to ensure adequate flows to estuaries such as the Caloosahatchee Estuary, and water needed to prevent saltwater contamination, such as occurs in the Caloosahatchee River in the vicinity of public water supply intakes in Lee County.

Minimum Flows and Levels - Significant Harm Standard

The District is responsible for the implementation of statutory provisions in Chapter 373, F.S., including Section 373.042, F.S., which requires that the District establish MFLs for watercourses and aquifers. Generally stated, the MFLs for a given watercourse or aquifer shall be the limit at which further withdrawals would be significantly harmful to the water resources of the area. As a step toward meeting the statutory requirement, a technical document was developed (SFWMD, 2000e) to identify proposed minimum level depth, duration, and frequency criteria for Lake Okeechobee, the Everglades and the Biscayne aquifer The remaining Everglades include the Water Conservation Areas (WCAs), the Holey Land and Rotenberger Wildlife Management Areas (WMAs), and the freshwater regions of Everglades National Park. The District is also proceeding with efforts to develop MFLs for associated areas, such as the Caloosahatchee River and Estuary, by 2000, the Loxahatchee and St. Lucie estuaries by 2001, Florida Bay by 2003, and Biscayne Bay by 2004.

Technical Criteria

As a first formal step to meet the deadlines for Lake Okeechobee, the Everglades and the Biscayne aquifer, the MFL report includes the following:

- A conceptual framework for determining MFLs based on the best scientific information and ecological criteria available (this approach may be applied to other surface and ground waters within the District)
- A proposed definition of significant harm to water resources; i.e. a loss of specific water resource functions that takes multiple years to recover, which results from a change in surface water or ground water hydrology
- Proposed minimum water levels (depth, duration, and frequency) that should be met to protect water and related resources in Lake Okeechobee, the Everglades, and the Biscayne aquifer
- Proposed technical criteria that provide the basis for determining what actions should be taken to reduce the number of times the MFL criteria for Lake Okeechobee, the WCAs, Everglades National Park, and the Biscayne aquifer are not met

The proposed MFL criteria for Lake Okeechobee, the Everglades, and the Biscayne aquifer were based on a review of available scientific literature, historical water level and spatial (geographic) data, modeling results, expert opinion, and the results of recent water resource investigations. This information was compiled and analyzed to develop criteria that could be applied to Lake Okeechobee, Everglades peat and marl soils, and the Biscayne aquifer. Work to define the freshwater needs of coastal estuaries such as the Caloosahatchee, Loxahatchee, and St. Lucie estuaries, Biscayne Bay, and Florida Bay is ongoing.

Continuing technical review by additional scientists and concerned interests is an integral part of the MFL development process. The *Draft Minimum Flows and Levels for Lake Okeechobee, the Everglades, and the Biscayne Aquifer* (SFWMD, 2000e) was formally peer reviewed by numerous impartial scientists and technical experts who provided substantive comments concerning all aspects of the document. The document was expanded and rewritten and the final report is referenced in this plan. Further refinements of these documents are anticipated through time.

Recovery and Prevention Strategy

Once the MFL technical criteria have been established, the District must develop a recovery and prevention strategy for those water bodies that do not meet the proposed criteria now or in the future (Section 373.0421, F.S.). The actions required to achieve MFLs will be laid out in this recovery and prevention strategy. This recovery and prevention strategy must be expeditiously implemented and include water resource development projects, development of additional water supplies, and implementation of conservation and other efficiency measures. The recovery or prevention strategy must include phasing or a timetable for development of sufficient water supplies for all existing

and projected reasonable-beneficial uses. Development of additional water supplies "concurrent with, to the extent practical, and to offset, reductions in permitted withdrawals . . ." (Section 373.0421, F.S.) must occur pursuant to the recovery and prevention strategy. The recovery and prevention strategy is included in the LEC Plan (**Appendix J**). This strategy includes implementation of the MFL criteria through rulemaking, which will occur subsequent to the planning process.

Comprehensive Everglades Restoration Plan Restoration Targets

The recommendations made in the Restudy will be refined and implemented within the Comprehensive Everglades Restoration Plan (CERP). While one goal of the CERP is the ecological restoration of the Everglades, this plan, as well as the broad scientific community, recognize that complete ecological restoration in this region is not possible. Traditionally, restoration has been defined as the recovery of a natural system to a condition that existed during some prealtered period. For the Everglades, this goal may require the creation of a system that mimics natural conditions that existed prior to construction of the first drainage canals and levees in the 1880s.

For at least two overwhelming reasons this goal is challenging. First, there have been substantial and irreversible reductions in the spatial extent of the wetland systems in South Florida (including an approximately 50 percent reduction in the extent of the true Everglades), and in the total water storage, timing, and flow capacities of these systems. The second major hurdle is that few of the quantitative, ecological characteristics of the predrainage wetlands of South Florida are known.

Because the predrainage Everglades cannot be recreated in its original form, the restoration goal for the CERP is to create a new Everglades that will be different from any system that existed in the past but will be substantially healthier than the current system. For this restoration project to be successful, it must recover important ecological indicators and patterns which are thought to have characterized the predrainage system, and it must be able to sustain these recovered ecological attributes over the long term.

It is too early in the South Florida ecosystem restoration process to state with certainty exactly what the endpoint for the restored Everglades should become. It is likely that the length of time required to implement the restoration projects, and the varying time lags in ecological responses, will mean that the current, managed system will evolve into a new Everglades. Thus, the point at which restoration is achieved, and the precise characteristics of that restored system, are unknown at present.

Because of these considerations and uncertainties, ecosystem restoration in South Florida is viewed as an open-ended process. Restoration planning is a balancing act among directions of change, general features that should be present in a restored system, flexibility concerning how and when certain objectives are achieved, and what the restored system should look like.

More importantly, the realistic perspective at present is that it is premature to force the debate over the question of, "what constitutes restoration?" At this point there is broad

agreement that water management and development practices have caused much of the ecological damage to the South Florida ecosystem and that restoration projects to correct hydrological stresses should produce strong improvements in the health of these existing ecosystems.

Evaluation Tools (Step 2)

Computer models were used extensively to help in develop this plan. Modeling efforts for the LEC Plan included same basic tools that were used for the Restudy. The models produce a simplified version of the real world that may be used to predict the behavior of the natural system under various conditions. The models do this through a series of equations which simulate major components of the hydrologic cycle in South Florida. These components include rainfall, evapotranspiration, infiltration, overland and ground water flow, canals, canal-ground water seepage, levee seepage, and ground water pumping. The models incorporate current or proposed water management control structures and current or proposed operational rules. Information from local comprehensive plans, utilities, the University of Florida Institute of Food and Agricultural Sciences (IFAS), and the District's permitting data base was used to support this analysis. Where specific information was not available, conservative professional judgement was used. While results of these model runs and analyses are an important part of the LEC planning efforts, the model runs do not constitute a plan. Instead, the analyses provide support for many of the plan's recommendations.

These analyses were conducted using both regional surface water and high-resolution ground water computer models. The regional South Florida Water Management Model (SFWMM) was used to understand how changes in the Central and Southern Florida Project for Flood Control and Other Purposes (C&SF Project), Lake Okeechobee, and WCA schedules and other factors might affect the hydrology of the region and its ability to supply water. The regional Natural System Model (NSM) was used to simulate conditions that may have existed in South Florida before water management features were constructed. The subregional. high-resolution ground water models were used to identify potential impacts of water use on the environment and ground water resources in the urban and agricultural areas along the lower east coast of Florida. Outputs from these models were also analyzed to identify areas where the potential for future saltwater intrusion exists in the Surficial Aquifer System.

South Florida Water Management Model Version 3.7

The South Florida Water Management Model version 3.7 (SFWMM v3.7) is a regional-scale computer model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh or grid of two mile by two mile cells. The model boundaries include Lake Okeechobee, the Everglades Agricultural Area (EAA), the WCAs, Everglades National Park, the LEC urban areas, and parts of the Big Cypress National Preserve (**Figure 8**). Inflows from Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie Canal basins are considered. The model simulates

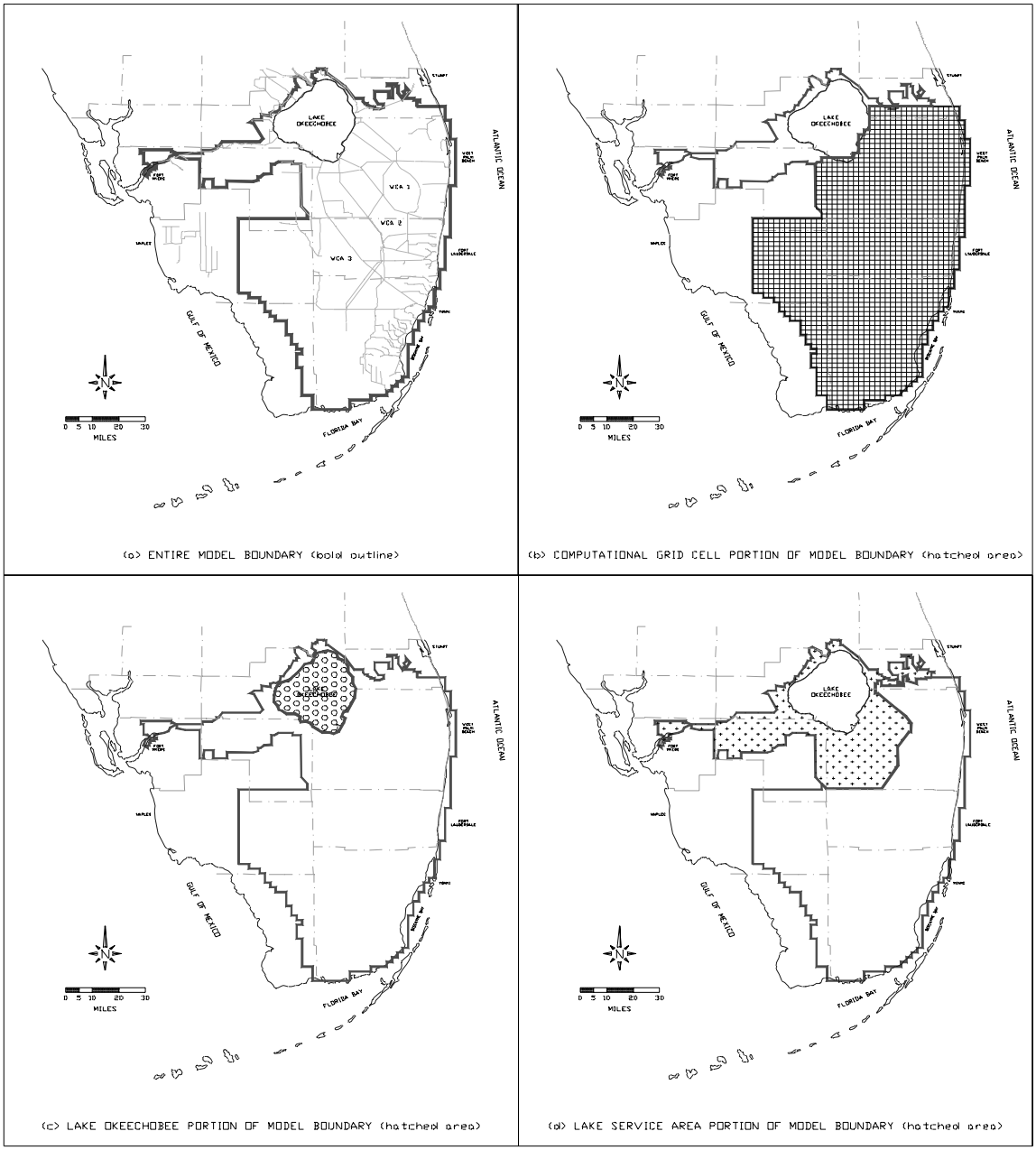

Figure 8. Boundaries and Grid Used for the SFWMM Simulations.

major components of the hydrologic cycle in South Florida including rainfall, evapotranspiration, infiltration, overland and ground water flow, canal flow, canal-ground water seepage, levee seepage, and ground water pumping. It incorporates physical and operational features for current or proposed water control structures, pump stations, and canals. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in South Florida is a major strength of this model.

The SFWMM is an integrated surface water-ground water model that simulates hydrology on a daily basis using climatic data for the 1965-1995 period, which includes droughts and wet periods. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. Output of the model includes Lake Okeechobee stages and discharge information, surface and ground water levels, overland flow, and evapotranspiration at any of the 1,700 four-square-mile model grid cells located within the LEC Planning Area. The SFWMM was developed in the early 1980s by the District for the USACE and has been extensively modified and improved during the past 14 years. The model has been used for a number of applications to evaluate proposed structural or operational changes to regional water management facilities. The SFWMM was used to help identify water supply problem areas in the LEC Planning Area and to assist staff in the evaluation of the five proposed water supply plan alternatives. Technical staffs of many federal, state, and local agencies, and public and private interest groups have accepted the SFWMM as the best available tool for analyzing regional-scale structural and operational changes to the complex water management system in South Florida.

The SFWMM was used in this plan because the hydrology of South Florida is complex, due to the flat topography, high water table, sandy soils, and high conductivity of the aquifer system. With the rapid population growth, the water control system in South Florida has been expanded and its operation has become increasingly automated, resulting in a unique system. Federal and state agencies, local governments, and private interests are presently involved in numerous environmental restoration and water resource development projects that are necessary to sustain the quality of life in this rapidly growing region. These projects can potentially cost billions of dollars, so that accurate estimation of their benefits and costs is extremely important. Simulation models have become the preferred means to assess systemwide impacts of the proposed modifications to the water resources system in South Florida. The SFWMM, developed specifically for this region, is probably the best available tool that can simulate the complex system features and operational rules of proposed regional water management alternatives and provide adequate information for making water management decisions.

Natural System Model Version 4.5

The Natural System Model (NSM) was created primarily to estimate natural predrainage flows and stages throughout the region, prior to significant human influence on the landscape. The current NSM (version 4.5) uses the same calibrated algorithms as those implemented by the SFWMM to represent surface and ground water flows, but the canals and structures of the C&SF Project, as well as all of the water supply wellfields, were removed. Data (where available) and estimates of presubsidence topography and an approximation of historical vegetation cover are used in lieu of the SFWMM data sets. Output from the NSM includes surface water and ground water levels, overland flow, ground water flow, and evapotranspiration.

The NSM uses recent rainfall data (1965-1995) to predict how water would move through an unmodified South Florida hydrologic system. The NSM is the most comprehensive tool available that describes the hydrology of South Florida prior to human

influence. The NSM provides a reasonable estimate of hydrologic patterns that should be used as restoration targets. The model was especially useful for Everglades ecosystems in the Holey Land and Rotenberger WMAs, WCA-1, WCA-2, WCA-3, Everglades National Park, and Big Cypress National Preserve. Many improvements have been made since the NSM was first developed. These improvements were based on comments and suggestions received from scientific and technical peer reviewers, and improved information, such as better topographic data. The District has elected to use the improved versions of the model as they became available. Outputs from the most recent version of the model provided a basis for the Everglades performance measures used in the LEC Plan.

In this study, NSM results were used in three ways. First, NSM predictions of hydropattern conditions were used to identify when deliveries of water should be made to the Everglades for environmental enhancement. Second, NSM hydropattern predictions were incorporated into the rainfall driven schedules. Finally, NSM hydropatterns were used in performance measures as reference points to estimate the degree to which the various alternatives achieve hydropattern restoration goals. NSM results have become accepted by the scientific community as reasonable estimates of natural hydrologic patterns that can be used as restoration targets, for the Holey Land and Rotenberger WMAs, the WCAs, and Everglades National Park.

The SFWMM and the NSM computer models perform, on a daily time step, a continuous simulation of water conditions based on 31 years of historic rainfall and evaporation data. The NSM covers an additional 1,576 square miles of portions of Glades, Hendry, and Highlands counties that were tributary to the original Everglades (**Figure 9**). Because of the limited amounts of historical predrainage hydrologic data available, NSM results cannot be directly calibrated to, or validated against, predrainage hydrologic conditions. As a result, NSM results are somewhat less certain than the SFWMM results. However, the NSM is considered the best tool available, combined with good scientific judgment, to estimate the hydrologic patterns needed to restore the remaining Everglades.

Subregional Models

Ground water models used in the development of the LEC Plan include six subregional models: five overlapping ground water models that extend from Palm Beach County's northern border to the tip of Florida and an integrated surface and ground water model that simulates the Caloosahatchee River Basin. These models were integral to development of the recommendations of the LEC Plan. They provided the initial design and local evaluation to support several recommendations of this plan. Specifications of the various models are summarized in **Table 4**.

The basins most dependent on ground water withdrawals to meet urban and agricultural demands require a higher-resolution model than the SFWMM's two-mile by two-mile grid to more precisely simulate the effects of withdrawals from the surficial aquifer system. The existing and proposed withdrawal facilities, may potentially impact the environment or aquifer or may not be able to meet the demands during a 1-in-10 year drought condition. In locations where potential impacts were most likely to occur, more detailed analyses were conducted.

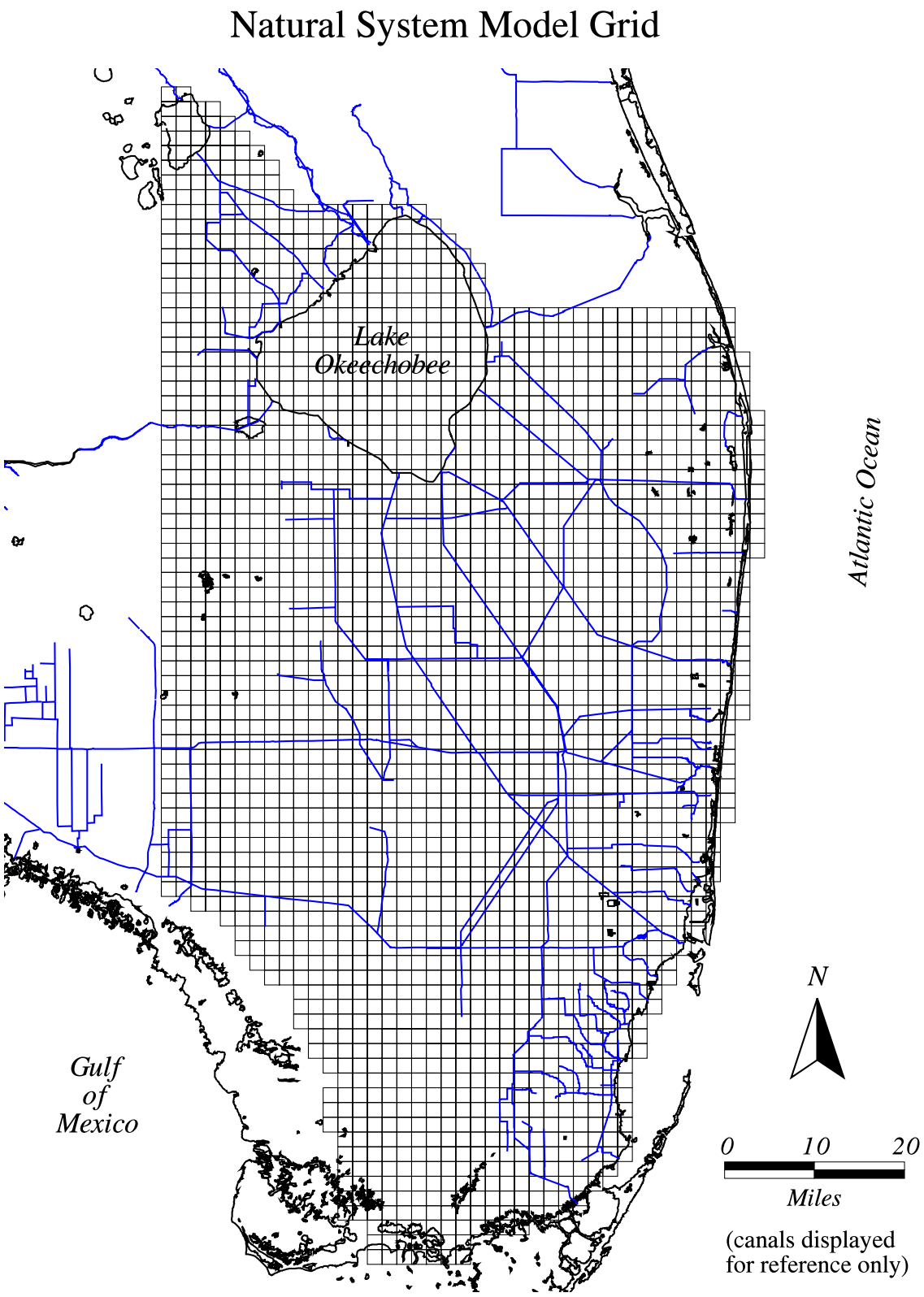

Figure 9. Boundaries and Grid Used for the NSM Simulations.

Table 4. Specifications of the High-Resolution Ground Water Models.

Model	Resolution	Calibration period(s)	Primary Developers
North Palm Beach (expanded)	1/4 mile	1987-1995	SFWMD
South Palm Beach	500 ft.	July 1988-June 1989 (dry) July 1994-June 1995 (wet)	SFWMD
Broward	500 ft.	1988-1992	Jointly by Florida Atlantic University (FAU) and SFWMD
North Miami-Dade	500 ft.	July 1988-June 1989 (dry) July 1993-December 1994 (wet)	SFWMD
South Miami-Dade	500 ft.	1988-1992	Jointly by FAU and SFWMD
Caloosahatchee MIKE-SHE	1500 ft.	1986-1990 1994-1998	Contracted to Danish Hydraulic Institute (DHI)

Five regional ground water models were used to simulate the potential impacts of water use in the LEC Planning Area: the North Palm Beach Ground Water Model, the South Palm Beach Ground Water Model, the Broward Ground Water Model, the North Miami-Dade Ground Water Model, and the South Miami-Dade Ground Water Model. These models use the United States Geological Survey (USGS) modular three-dimensional finite difference ground water flow model, commonly known as MODFLOW. The area encompassed by each model is divided into cells by a model grid (defined by a system of rows and columns). Each cell is 500 feet by 500 feet. (The Northern Palm Beach model which has a grid size 1/4 mile by 1/4 mile.) The higher resolution of the MODFLOW models is captured by the fact that approximately 450 ground water model cells can fit into one SFWMM cell. The grid also has a third-dimension, depth. The number of layers and thickness of each layer vary within the models and between the models depending on the characteristics of the aquifer. The ground water models generate two principal types of output: computed head (water levels) which result from the conditions simulated, and water budgets for each active cell. The water budget shows the inflows and outflows for each cell. More detailed information on these models is available in **Appendix F**.

Due to the integrated nature of the surface water and ground water resources in the Caloosahatchee River Basin, an integrated approach has been adopted using MIKE-SHE. The integrated surface-ground water model includes the freshwater portion of the basin, which stretches from Lake Okeechobee upstream, to the Franklin Lock (S-79) downstream. The model area encompasses approximately 1,050 square miles (2,720 square kilometers). Details of Caloosahatchee Basin modeling efforts are described in the CWMP (SFWMD, 2000d).

An important component of the evaluation process for the LEC Plan is the analysis of the estimated costs associated with each option and each alternative. While hydrologic modeling is used primarily to evaluate the relative performance of options and alternatives in meeting the water resource management goals, the cost analyses specify, at a planning level, the present and future costs of the resources needed to achieve that performance. Cost estimates for the LEC Plan were mainly developed using analyses completed for the Restudy. The planning level costs developed for the LEC Plan were based on the options

presented in the appendices to this document that identify major cost components. These components, such as acres of land, miles of levees of certain height, pump stations of certain capacity, or wells of certain depths and sizes, were then used to estimate the costs of options. These procedures are only designed to provide planning level costs that are useful to compare relative costs among options or alternatives. More detailed designs and analyses of site specific factors will be needed before costs suitable for actual construction can be developed.

Categories of costs in the analyses include land purchases, construction of structures and facilities, and operation and maintenance. The estimated costs and cost savings resulting from the implementation of any option represent differences from the future base condition. No costs for existing programs, such as the Everglades Construction Project, are included as costs in the LEC Plan.

Performance Measures (Step 3)

Establishing Performance Measures

Once the goals, objectives, and modeling procedures were established for the LEC Plan, measures were defined to assess performance of the water supply system. A comprehensive set of performance measures was developed by District staff with review and input from the LEC Regional Water Supply Plan Advisory Committee. The performance measures indicate the degree to which the options and alternatives are likely to meet the goals and objectives of the plan. The performance measures are represented by specific, selected outputs of the NSM, SFWMM, the ground water models, and their postprocessing.

Certain specific performance measures are considered key measures because they best summarize the overall performance of alternatives. They are presented along with the discussion of the results in **Chapter 4**. A more complete description of performance measures is provided in **Appendix D** and results of those measures for the various model runs are presented in **Appendix H**.

Categories of Performance Measures and Indicators

The main categories of performance measures and indicators include water budget summaries, inflow measures, outflow measures, water level measures, demands met (or not met) measures, and measures that compare projected water levels with MFLs and NSM predicted hydroperiod (depth, duration, and frequency) targets. A summary of each of these categories and their importance is provided below.

Water Budget Measures

Water budgets are summaries of the major inflows and outflows of water in a basin. Rainfall, evapotranspiration, and inflows and outflows of surface and ground water across basin boundaries are the major components. Water budgets provide an important

basis for comparing the sources and uses of water in different water management alternatives. For instance, the water budgets for Lake Okeechobee provide an important basis for evaluating use of lake water.

Inflow Measures

Inflow measures are summaries of the timing (frequency and duration), amount, and location of water flowing into a basin. These measures are important because the timing, amount, and location of inflows into natural areas affect the degree to which desired hydroperiods, MFLs, and restoration can be achieved. For example, the proportion of inflows that enter Everglades National Park through eastern and western portions of Shark River Slough is a major indicator of the ability to restore sheetflow through Everglades National Park. Inflows are also important performance measures because they can measure demands. Inflows to the coastal basins during drought periods indicate the demands of the coastal basins for regional system water.

Outflow Measures

Outflow measures are summaries of the timing (frequency and duration), amount, and location of water flowing out of a basin. Outflow measures from wetland basins are important because releases of water affect the ability to meet hydroperiod goals in those basins that supply the water. For instance, seepage out of the Everglades to the coastal basins has a major impact on the ability to achieve desired hydroperiods in the Everglades. Outflows from reservoirs to meet demands are key measures of the performance of the reservoirs.

Water Level Measures

Water level measures are summaries of water elevations. In wetlands, the depth, frequency, and duration of inundation (hydropattern) are particularly important performance measures. Stage hydrographs and stage duration curves are two important means that are used to present water level measurements. Water level measures are also used to determine how much water is in the system. Such data indicate if problems may be occurring due to excessively wet or dry conditions.

Measures of Demands Met and Demands Not Met - Level of Certainty

Measures of demands compare the amounts of water supplied to users with the amount of water that is desired or normally used. Measures of demands that are met and demands that are not met are particularly important as a means to assess the performance of the option or alternative relative to meeting urban and agricultural water demands. The present water management response to anticipated water supply deficits is to declare water shortages, shift supplies, limit deliveries, and reduce demands. The intent of District planning efforts is to implement long-term water resource development projects that will eventually provide enough additional water to meet demands during a 1-in-10 year drought condition. Therefore, the frequency and duration of declared water shortage restrictions are used as performance measures. The District has the ability to impose

several different levels of water restrictions. Phase 1 and Phase 2 shortages are less severe and unlikely to cause economic loss or damages to crops or vegetation. Phase 3 and 4 restrictions are more severe and may reduce irrigation to the extent that crop and vegetation damages would be significant if rainfall cannot compensate for the lack of irrigation water.

The level of certainty planning goal that the districts need to achieve in their water supply plans is to provide sufficient water to meet the 1-in-10 year level of certainty criteria (Section 373.0361, F.S.). This criterion was applied as an additional performance measure to evaluate the adequacy of water deliveries to utilities and agricultural water users.

Measuring MFLs

Specific quantitative targets have been proposed for minimum levels in Lake Okeechobee, the Everglades, and the coastal Biscayne aquifer. Comparison of projected water levels for an alternative to these targets is an important performance measure to determine where and when significant harm may occur.

Natural System Model Hydroperiod Targets

Similarly, the NSM was used in many areas to define restoration and management goals. Generally these targets were considered to provide the harm standard that is used to establish limits for issuing consumptive use permits. Many such comparative performance measures are used for evaluation of the LEC Plan options and alternatives.

Estimate Current and Future Base Case Conditions (Step 4)

Current base case conditions consisted of 1995 land use patterns and populations, as well as actual water use data provided by local utilities. This model run was the 1995 Base Case. Two future base case conditions were considered.

In the first future condition, projected 2020 land use patterns, population distributions, and water use data were developed based on input from local governments, utilities, and the state. Ongoing efforts such as the Everglades Construction Project, C-111 Project and Modified Water Deliveries to Everglades National Park are assumed to be complete. This constituted the 2020 Base Case, which does not include Restudy projects.

In the second future condition, projected 2020 land use, population, and ongoing project conditions were also used. Water supply and environmental restoration components recommended in the Restudy were then added to the extent that such facilities or features would be in operation by 2020 to create the LEC 2020 with Restudy.

This second future condition was also evaluated using the subregional ground water models. Outputs from the 2-mile by 2-mile grid SFWMM were used to establish boundary conditions for the finer scale subregional models. Outputs from the subregional

models were expressed and evaluated in terms of the same performance measures that were used for the larger models

Problem and Solution Identification and Evaluating Alternatives (Steps 5 Through 8)

Having identified the problems based on historical experience and the base case evaluations, the next step was the identification of potential solutions that would provide the water needed to meet the projected demand. In the LEC planning process, individual actions that may contribute to an improvement in water supply are called options. When selected options are combined to improve the overall performance of the water supply system, they are referred to as an alternative.

Results of the Restudy and input from the LEC Regional Water Supply Plan Advisory Committee were used as the primary basis to identify options and develop alternatives. Options were identified based on performance problems discovered in the base case analyses or from evaluation of previous or parallel planning efforts. Also considered was the potential or opportunity that exists for the option to solve the problem, the technical feasibility, ability to obtain permits, and the cost of the option.

The identification of an option within a particular area is based on the recognition that there is an opportunity to improve on the management of the regional water system. It does not imply that a problem is or is not caused by water demands in that area or that a special funding responsibility will or will not be assigned in the area where a facility is located. Many of the options included in this plan have been identified as components of the Restudy. To the extent possible, the methods and procedures that were used to analyze options for the LEC Plan were the same as were used for the Restudy. Examples of water resource development opportunities that will improve the regional water management system include the following:

- Facilities or operating procedures to modify storage in Lake Okeechobee
- Facilities to capture and use runoff from the Caloosahatchee Basin
- Aquifer Storage and Recovery (ASR wells) and reservoirs to capture and use runoff from the EAA
- Water Preserve Areas (WPAs) to capture and use seepage from the Everglades and runoff from coastal basins
- Facilities and operating procedures to improve the timing and location of releases into the Everglades and between locations within the Everglades
- Operational procedures to improve timing and location of releases to estuaries

In addition to the regional elements that were considered in the Restudy, a number of more site-specific features were analyzed to help meet urban and agricultural needs in coastal watersheds and the EAA:

- Wellfield relocation to protect and make better use of water resources available in the coastal basins
- Local ASR to capture and use excess water
- Alternative sources to meet new water demands in the EAA and coastal basins

Options considered in the LEC Plan are discussed in **Chapter 5** and detailed explanations are included in the appendices to this report.

Recommendations (Step 9)

Initial draft recommendations were developed by District staff based on all the analyses conducted in support of the LEC planning process, discussions with the LEC Regional Water Supply Plan Advisory Committee, and comments and input provided by the committee and the public throughout the planning process. The Restudy components primarily address environmental restoration goals, but also provide significant regional urban and agricultural water supply benefits. The final recommendations were also based on results of model runs and the findings and insights gained throughout the entire LEC planning process.

Implementation Plans and Funding Analyses (Step 10)

Detailed funding analyses and schedules to implement the recommendations in the LEC Plan were developed as a component of this plan. Planning level implementation steps and costs were developed in concert with the Restudy and were based on results of model runs and staff analysis. Funding strategies for the LEC Plan are being coordinated with other Districtwide activities, efforts of other agencies, local governments, and utilities.

PUBLIC AND GOVERNMENT PARTICIPATION

The LEC Regional Water Supply Plan Advisory Committee was created in January 1992 to allow extensive public participation in the plan development process. The committee has played a key role throughout the planning process, especially in assisting with the development of objectives and design solutions to meet the objectives. Committee participants include representatives from urban, agricultural, environmental interest groups, government agencies, Native American tribes, and others. A continuing role of the LEC Regional Water Supply Plan Advisory Committee is to represent the public in the implementation of the regional water supply plan.

To encourage and ensure a high level of public participation, the SFWMD has met with many groups and organizations to discuss this plan. Participants included utility, environmental, and agricultural advisory committees, the Governor's Commission for a Sustainable South Florida, the Southeast Florida Utilities Council, and the Florida Section of the American Water Works Association (AWWA). The SFWMD also contributed significant support and technical information derived from the LEC planning effort to the Governor's Commission for a Sustainable South Florida, the Northwest Dade County Freshwater Lake Plan Implementation Committee, the planning effort for the WPAs, and the Restudy.